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Guidelines for Health Surveillance in the NASA (National Aeronautics and Space Administration) Workplace

National Research Council, Washington, DC

Prepared for

National Aeronautics and Space Administration
Washington, DC

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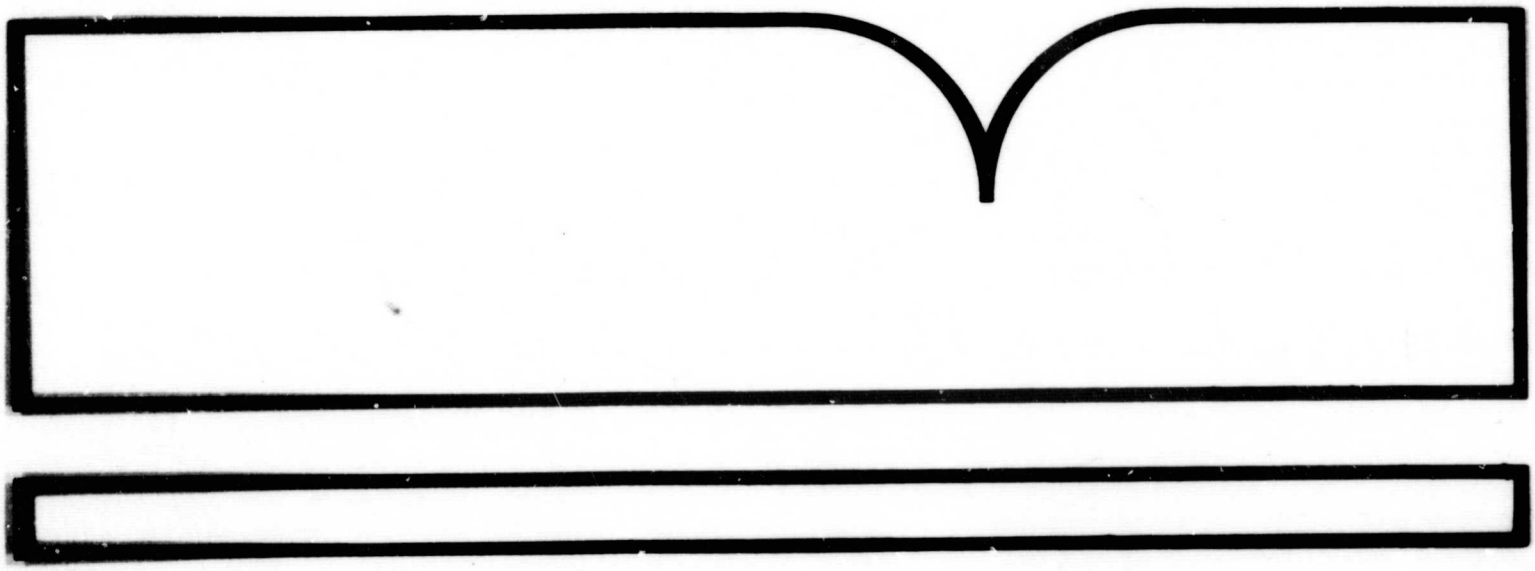

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GUIDELINES FOR HEALTH SURVEILLANCE IN THE NASA WORKPLACE

Prepared for the

National Aeronautics and Space Administration

by the

Subcommittee to Evaluate NASA Medical Surveillance Data Sheets

COMMITTEE ON TOXICOLOGY

Board on Toxicology and Environmental Health Hazards
Commission on Life Sciences
National Research Council

National Academy Press
Washington, D.C.

February 1984

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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PREFACE

The task assigned to the National Research Council Committee on Toxicology proved to be a challenging one. We were presented with the description of an occupational health program developed by the National Aeronautics and Space Administration (NASA) and applied to about 50,000 employees and contractors in operating facilities around the country over a period of several years. Health services available to NASA employees have included periodic medical examinations planned primarily for purposes of personal health maintenance, with less emphasis on the need to maintain medical surveillance of those workers who had actual or potential exposure to hazardous chemical or physical agents. Recommended NASA examinations have been of rather elaborate scope, including a variety of laboratory procedures now recognized, as a result of observations by the Canadian Task Force on the Periodic Health Examination (1979) and by others, as having little clinical justification as routine procedures for well persons. The cost effectiveness of such procedures has also been challenged. Yet the physical and financial burden of carrying out a large volume of such routine examinations tended to overwhelm the desire and the capacity of the NASA medical staff to carry out limited examinations of specifically targeted scope on those workers exposed to hazardous conditions of work.

Members of the study subcommittee, representing several medical specialties, reviewed materials submitted by NASA and met with medical and industrial hygiene representatives of NASA to discuss past and existing practices of medical surveillance and personal health maintenance. In a series of meetings, the subcommittee then considered NIOSH guidelines and other recommendations for appropriate medical procedures. This report is the result of those deliberations.

I wish to express my deep gratitude to my distinguished colleagues on the study subcommittee who contributed so generously of time and effort in this task, and especially to Dr. Leonard T. Kurland, who was also a member of the parent Committee on Toxicology.

Members of the NRC staff were exceedingly helpful, including Gary R. Keilson, Project Director, whose background in the health sciences proved invaluable.

James P. Hughes, M.D.
Chairman
Subcommittee to Evaluate NASA
Medical Surveillance Data Sheets

EXECUTIVE SUMMARY

The Committee on Toxicology (COT) of the National Research Council Commission on Life Sciences was asked by the National Aeronautics and Space Administration (NASA) to evaluate current procedures used for preparing medical surveillance data sheets that are used by examining physicians at NASA. The data sheets contain information of value to the physician in determining possible consequence of exposure to workplace chemicals.

The study, begun in December 1982, required the formation of a subcommittee of appropriate medical specialists in addition to members of the COT and its staff.

The specific charge to the subcommittee was to assess the adequacy of the current data sheets and suggest changes in design and content if such modifications would improve the guidance offered to physicians.

The subcommittee, on reviewing procedures for developing medical histories and medical examinations, toxicity information and test methods, concluded that:

1- Medical surveillance toxicity data sheets should be authoritative and useful to a physician in predicting possible effects from exposure; they should be useful for making decisions about periodic screening or for coping with overexposure; they should be validated by experts.

2- NASA should develop a computerized medical-record-keeping system for its employees which would serve a variety of purposes.

3- Workers should be informed of potential hazards of materials they are exposed to, encouraged to work safely, and keep informed of results of medical tests.

4- Some follow-up examinations should be considered after employment is terminated.

CONTENTS

INTRODUCTION

Awareness of the potential adverse health effects of workplace exposure to chemical and physical agents has been increasing in recent years. According to the Environmental Protection Agency (EPA) and the National Institute for Occupational Safety and Health (NIOSH), some 45,000 chemicals and 250,000 formulated products are used commercially. Some are known human toxicants, others have been shown to be toxic to experimental animals. But few are widely subjected to medical surveillance for adverse effects. The Occupational Safety and Health Administration (OSHA) has promulgated health standards requiring medical examination for workers exposed to any of 24 substances. NIOSH recommends medical screening for workers exposed to any of 400 other substances. These recommendations are contained in NIOSH criteria documents or were proposed in the NIOSH/OSHA Standards Completion Project. Some employers provide periodic voluntary medical examinations of exposed workers, and a few labor organizations endorse these through the use of union-management health and welfare funds.

In recognition of potential occupational health hazards, the National Aeronautics and Space Administration (NASA) has instituted several health and safety programs for its employees. NASA was established by Congress in 1958 as an independent civilian agency in the Executive Branch. Its headquarters are in Washington, D.C., and it has 11 major field centers and several component installations. About 23,000 NASA employees and about 30,000 contractor employees work at the various installations.

NASA's health and safety programs vary in content and depth among the installations, but the basic components include:

- Safety Program--Concerns provision of a safe work environment and prevention of job-related accidents.
- Occupational Medicine Program--Includes job-related medical examinations, health education, physical-fitness programs, screening tests for specific diseases, and emergency treatment.
- Environmental Health Program--Includes identification of potential health hazards and implementation of control measures to minimize and prevent exposure.

NASA recently began to develop medical surveillance data sheets to provide specific guidance to its occupational physicians on chemical and physical agents most often encountered in the workplace. It has developed data sheets on 55 chemical and physical agents. Initial drafts were prepared by a consultant in occupational medicine; revisions were later prepared by NASA's medical staff.

NASA has asked the National Research Council (NRC) to assess the procedures used to develop the data sheets and to suggest changes in their design and content that would improve the guidance offered to physicians. It has also asked for suggestions of ways to improve collection, analysis, and management of medical data. Administrative

responsibility for this task was assigned to the Committee on Toxicology of the Board on Toxicology and Environmental Health Hazards, in the NRC Commission on Life Sciences. The Committee delegated primary responsibility for this task to the Subcommittee to Evaluate NASA Medical Surveillance Data Sheets, consisting of experts in occupational medicine, epidemiology, clinical pathology, toxicology, and internal medicine.

The Subcommittee reviewed sample data sheets on asbestos, 4,4'-methylenebis(2-chloroaniline), dichlorofluoromethane, formaldehyde, and hydrazines. It also was briefed by NASA officials on the status of medical recordkeeping and future needs in that field.

GUIDELINES FOR GENERAL MEDICAL EXAMINATIONS-- PREPLACEMENT AND PERIODIC

NASA's guidelines for general medical examinations, as part of preplacement screening and for periodic health examinations of those already employed, provide for both personal health maintenance and early detection of work-related abnormalities. Although this comprehensive approach has merit, it tends to obscure the primary mission of the occupational-health team: health effects of work exposure to potentially hazardous agents. When a broader scope of examinations for personal health maintenance is possible, recent critical reviews (described below) of the efficacy of component procedures should be considered.

PERIODIC EXAMINATIONS

The Canadian Task Force on the Periodic Health Examination (1979) reviewed data regarding the mortality, morbidity, and disability ascribable to 78 selected target conditions and evaluated the potential efficacy of therapeutic interventions. The Task Force grouped the interventions that were found to be efficacious into 18 health-protection measures to be performed at 35 specified times between infancy and old age. These recommendations have become important factors in modifying general attitudes to periodic health examinations and guiding many physicians in their utilization of medical history, physical examination, and laboratory tests. Breslow and Somers (1977) described a similar set of periodic health examinations and also suggested a large reduction in the amount of routine screening of the asymptomatic population. Recent recommendations on this subject have also been made by the Council on Scientific Affairs of the American Medical Association (1983). The AMA emphasized that periodic medical evaluation of healthy persons "is important for early detection of disease and for the recognition of certain risk factors that may presage disease." It concluded that the frequency of periodic examinations and the procedures employed will vary, depending on such factors as age, heredity, occupation, and socioeconomic status. Some general recommendations were provided on the frequency of examinations and on test procedures to be performed.

None of these sets of recommendations, however, specifically took into account the special demands placed on an agency attempting both to safeguard the health of its workers and to establish a baseline for determination of the impact of hazardous exposure. Although the Subcommittee accepts the general principles of the Canadian Task Force and others, the scope of the preplacement and periodic examinations should be expanded to include factors of occupational significance.

PREPLACEMENT EXAMINATIONS

Unlike general examinations for screening the population at large, preplacement screening for NASA should establish a clear baseline with regard to potential hazard for the employee. The history taken at initial examination should include a detailed account of the person's medical, family, social, and occupational history, as well as a comprehensive review of organ systems. The occupational history should include documentation of exposure to workplace hazards--physical, environmental, and chemical exposures. In particular, if the position in NASA for which the applicant is being screened includes exposures to similar occupational hazards, efforts should be made to obtain occupational-health data from the place of employment where the prior exposure took place.

The preplacement examination should include the remainder of a complete physical examination, including examination of head, scalp, eyes, ears, nose and throat, chest and lungs, heart, abdomen, genitalia, rectum, extremities, and skin; neurologic examination--assessment of motor strength of biceps, triceps, grip, and quadriceps; sensory evaluation for vibration, pin, and light touch; deep tendon reflexes of the brachioradialis, quadriceps, and achilles; assessment of the plantar response; analysis of cranial nerve function; and mental status assessment with standardized brief cognitive-function testing. At the University of Washington, a 55-step screening physical examination has been developed that can be completed by a skilled occupational-health person in a short period.

For health maintenance, recommendations of the American Medical Association and the Canadian Task Force on immunizations and general health counseling should be considered.

Hypothetically, the physician may be able to detect--through medical histories, physical examinations, and laboratory studies--a subset of the population that is at higher risk or that presents a risk to others by virtue of an existing disease or a predisposition to disease or injury. Examples are a day-care worker with tuberculosis and a person with a seizure disorder who works with machinery.

Some workers are also excluded from employment because hypersusceptibility to disease or injury is presumed on the basis of inappropriate tests or misinterpretation of results. For example, routine preplacement radiography of the lumbar spine is still practiced in some industries with a tendency to exclude from many jobs applicants with even minor congenital vertebral variations. There is a lack of evidence that such intervention is effective in preventing back injuries. Given the lack of consensus of what constitutes hypersusceptibility in workers, the occupational physician should avoid exclusionary policies that are not clearly effective in preventing disease or injury.

LABORATORY INVESTIGATIONS

Laboratory studies should be limited to those relevant to anticipated exposure to potentially toxic agents. Recommendations of the Canadian Task Force and others should be tempered by the need to select tests that can identify workers who will be particularly susceptible to the effects of hazardous exposure, e.g., decreased hearing in a worker who may be exposed to loud noise.

In contrast with the preplacement general examination, the periodic health examination should focus on the detection of conditions that, although they may not be treatable, would provide data useful in improving preventive strategies for other workers exposed to the same hazard. The choice of laboratory tests for the periodic examination must be tailored to the exposure to avoid generating excessive false-positive results while maintaining sufficient sensitivity to detect abnormalities that are truly attributable to the occupational exposure. Emphasis should be on identification of laboratory or physical abnormalities with an eye to direct intervention for specific workers or to improvement in preventive strategies in the workplace. Operational or placement decisions that flow from clinical or laboratory examinations and interpretations must have objective bases. The placement or nonplacement of a person for health reasons must be grounded in fact rather than speculation. Administrative decisions that are unsupported by medical evidence but claim "medical" bases have been a source of harm and litigation.

GUIDELINES FOR POTENTIALLY HAZARDOUS AGENTS

In addition to general preplacement and periodic medical examinations, NASA provides medical surveillance targeted to specific hazards in the workplace. The Subcommittee believes that the primary focus of the occupational-health team must be on the identification and control of potential health risks in the workplace. The occupational physician commonly faces a worksite with many potentially hazardous agents, few of which may be well known for their toxic properties and for fewer of which biologic monitoring and medical examination techniques are performed. The occupational physician usually depends on the industrial hygienist to identify and quantify these potential hazardous agents in the workplace, to evaluate the adequacy of engineering control measures, to test workers' personal environment to ensure that exposures are within acceptable limits, and sometimes to suggest analysis of body fluids (biologic monitoring) for evidence of absorption.

As a secondary defense, the occupational physician may examine and question workers for early signs or symptoms of disease, in addition to interpreting the results of biologic monitoring and perhaps providing other clinical laboratory tests. In this context, a worker with evidence of occupational disease represents a failure of primary prevention. In circumstances in which toxicity is not suspected, occupational disease may suggest the presence of a nonsuspected toxicant in the workplace. In either case, information on observed human harm not only must be used for the benefit of individual workers, but must be provided to those practicing primary prevention--the safety engineer and the industrial hygienist--with the goal of further control of exposure.

The medical surveillance data sheets developed by NASA provide to the occupational-health team valuable background and toxicity information on potentially hazardous agents and guidance on medical surveillance. This chapter, based on a review of a selected sample of NASA medical surveillance data sheets, is intended to guide NASA in futher development of such sheets. The major section headings generally follow the outline currently used in the data sheets and could serve as a useful format.

BACKGROUND INFORMATION

Physicians and other occupational-health practitioners are not likely to be familiar with the potential adverse health effects of many of the physical and chemical agents encountered in the workplace. Detailed knowledge of specific materials varies considerably, so it is best to assume that users of medical surveillance data sheets have only a limited familiarity.

The data sheets that have been prepared by the NASA medical staff are revisions of earlier drafts; all comments in this section are directed toward these revised data sheets. The background information is well organized, clearly presented, and adequately referenced. The following are offered as suggestions for incorporation into the data sheets.

SYNONYMS AND TRADE NAMES

It appears that sufficient information has been compiled, and no changes are suggested.

PHYSICAL FORM

This section should be expanded to include physical and chemical properties. A statement concerning the physical form of the material is helpful, but other information, such as molecular weight, chemical formula, chemical structure, boiling point, melting point, solubility, and vapor pressure would be useful to the reader.

EXPOSURE LEVELS

Exposure levels should be presented so that the terminology is clear, the applicability of the values is well understood, and differences in recommendations among agencies are explained. For example, the OSHA, NIOSH, and American Conference of Governmental Industrial Hygienists (ACGIH) recommendations for many materials differ. A brief explanation would give the reader a better understanding of the basis for the differences. The date when a given value was established should also be shown, so that the reader is aware of the currency of the information. The units for expressing airborne concentration should be consistent, so that comparisons can be readily made. Where applicable, concentrations of chemical agents should be expressed in both parts per million (ppm) and milligrams per cubic meter (mg/m^3). It also would be helpful to include the definitions of the OSHA and NIOSH permissible exposure levels, the ACGIH threshold limit values, and any other terms used by these groups.

EXPOSURE ROUTE

Information on the routes of entry into the body is important in suggesting the likely extent of exposure and what organs might be affected. In addition to the exposure routes, it would be helpful to state which are the most important routes and the likelihood of exposure by each route. For example, if skin is a possible exposure route, some information should be given on the likely extent of absorption and penetration of the material.

USES AND INCOMPATIBILITIES

These sections provide information on the major uses of the agent and on materials that, if they are present with the agent, could produce a potentially hazardous situation. For example, formaldehyde is incompatible with strong oxidizers, strong alkalies, acids, phenols, and urea. These sections are self-explanatory; no additional suggestions are offered.

TOXICITY INFORMATION

Two drafts of the sample data sheets were reviewed by the Subcommittee. In the first, the toxicity information was tersely summarized in a two- or three-sentence statement under the heading "Toxicity." The advantage of this approach is that the statement fits into the tightly structured outline of the entire data sheet; the disadvantage is that the capsular information does not provide sufficient guidance to NASA physicians. In the set of second drafts, the toxicity information was put forth in a loosely structured narrative under the heading "Toxicology and Medical Aspects." The toxicology section comprised three to six paragraphs of text and approximately a dozen bibliographic citations. The advantage of this approach is that the narratives provide more of the information that NASA physicians need for medical surveillance of workers who are exposed to the various substances; the disadvantage is that the narratives are not as authoritative as the comparable sections in standard texts of industrial toxicology (e.g., Proctor and Hughes, 1978; Finkel, 1983; Clayton and Clayton, 1981; Rom, 1982).

In the Subcommittee's opinion, the toxicity sections of the NASA medical surveillance data sheets should conform to the semioutline format characteristic of the other sections; they should supplement, rather than substitute for, standard texts, monographs, and criteria documents. (In those instances where other reviews are not available, the data sheets would need to be more comprehensive). To summarize the pertinent toxicologic data for NASA physicians in the most accessible fashion, the toxicity sections might be patterned on the familiar example of a medical case history. Whereas textbooks seldom include negative toxicity data, reliable information on the absence of toxicity in man and animals is important to NASA physicians. Therefore, like medical case histories, the NASA data sheets should aim for emphasis on positive and negative observations that might be related to exposures in the workplace. It would also be helpful to indicate where there are a lack of studies in critical areas. The length of the toxicity sections of the data sheets may vary widely, depending on the clinical substance in question, but there should be no hesitancy to refer to texts, monographs, and criteria documents for additional data and background information.

The following general outline is proposed for the toxicity section of the NASA medical surveillance data sheets:

- Abstract. This section, analogous to the list of "chief complaints" in a medical case history, should concisely itemize the major toxic hazards of the chemical substance in the workplace.
- Toxic Effects on Humans. This section should tabulate the toxic effects that occur in humans after acute or chronic exposures to the substance. If neither acute nor chronic effects of human exposures have been reported, the extent and reliability of the negative clinical data should be stated. The genetic, life-style, pharmacologic, or environmental factors that may influence human susceptibility to toxic effects of the substance should be mentioned.
- Epidemiologic Studies. This section should provide a synopsis of epidemiologic studies of human exposures to the substance, with particular attention to (a) the incidences of neoplastic, respiratory, cardiovascular, neurologic, reproductive, dermatologic, and allergic disorders in exposed workers and (b) correlations between exposure levels and specific incidence rates.
- Toxic Effects in Animals. This section should summarize (a) absorption, transport, distribution, metabolism, conjugation, deposition, and excretion, (b) LD_{50} values of the substance in experimental animals by various routes and dosage schedules, (c) characteristics of the toxic responses, (d) pathologic lesions in target tissues, (e) cellular and molecular mechanisms of toxicity, (f) correlation between dosage levels and toxic effects, and (g) evidence of synergism or potentiation by combined exposure to the substance and other chemical or environmental factors.
- Carcinogenicity, Mutagenicity, Teratogenicity, and Reproductive Effects. This section should summarize experimental data on genotoxic effects of the substance in animals, tissue-culture cells, and microorganisms. If carcinogenicity of the substance has been evaluated in an International Agency for Research on Cancer (IARC) monograph, the IARC conclusions regarding the evidence of carcinogenicity should be stated.
- Scientific Literature. In addition to the customary bibliography of cited articles, this section should specify whether the substance has been considered in a monograph or criteria document by such a group as NIOSH, OSHA, EPA, ACGIH, the National Academy of Sciences - National Research Council (NAS-NRC), the World Health Organization (WHO), or the Commission of the European Communities (CEC). Criteria documents from the other countries, such as Great Britain, Canada, Scandinavia, and Japan, should be included, as well as reference volumes on the substance and authoritative discussions in textbooks.

The toxicity section of each NASA medical surveillance data sheet should be updated by NASA staff every 2 or 3 years, and reviewed by persons thoroughly acquainted with the clinical and toxicologic literature on the relevant class of chemical substances. The names of the reviewers and the date of the review should be stated on each data

sheet. Pertinent new information should be inserted into the data sheets by NASA staff as it becomes available; such new information should be identified as an addendum to the preceding version of the document. More detailed comments on possible review mechanisms are provided in Chapter 5.

EXPOSURE HISTORY

PREPLACEMENT EXAMINATION

The goals of the preplacement examination are to avoid placement of workers in jobs to which they are unsuited for health reasons, to gather baseline information to assess the impact of later absorption of toxicants or resulting pathologic conditions, and to detect ill health that may have resulted from exposure.

The exposure history should be complete. If the employee is not certain about prior exposures, past employers should be queried. In view of the uncertainty of such exposure histories, documentation should be sought whenever possible.

If the effort to establish the exposure history is exhaustive, the occupational physician will be confronted with a multitude of chemical exposures. The assistance of industrial hygienists, toxicologists, and others may have to be sought to review the health implications of the exposures. The scope and detail of the preplacement examination should reflect prior exposures.

The occupational physician should know the specific risks of the particular jobs to which employees are to be assigned. For each hazard, the medical data sheet prepared with expert guidance will be needed to establish the appropriate baseline examinations and to establish which predisposing health conditions should contraindicate particular placements.

PERIODIC EXAMINATION

The goals of the periodic examination are to detect evidence of absorption of industrial toxicants, to detect early signs or symptoms of disease, to detect changes in the health of the employee since the preplacement examination that may require a change in job placement, and to provide data for the reevaluation of the plant's control of exposure. The occupational physician should depend on the employee and the industrial hygienist for a detailed inventory of job exposures. For each such exposure, there should be available for the physician a review of adverse health effects, contraindicated preexisting health conditions, and specified components of the history or physical examination effective in detecting pathologic conditions.

OVEREXPOSURE

For effective handling of accidental exposure, the nature of the chemicals involved in the exposure must be known and appropriate intervention must have been planned. The time of the exposure is not the appropriate time for research on the chemical constituents of a commercial product and for developing recommendations as to therapy. Hence, just as the occupational physician must be provided with details of specific exposure to guide the periodic examination, this information and detailed instructions on therapy must be available at the time of accidental exposure.

EXPOSURE HISTORY AT TERMINATION

At the termination examination, the exposure history since the previous periodic examination should be updated.

MEDICAL HISTORY AND PHYSICAL EXAMINATION

The preceding section on exposure history emphasizes that a detailed assessment of past exposures is necessary for appropriate placement of the employee and for guidance of the physician on laboratory tests, specific historical questions, and physical signs to look for. For each exposure, there needs to be a detailed review of potential adverse reactions, methods for early detection of pathologic conditions, predisposing conditions, etc. This review will determine the specific questions and signs to be selected in the clinical examination.

Standard sources that are available and will be of some value in this effort include the NIOSH criteria documents and Chemical Hazards of the Workplace (Proctor and Hughes); the latter is a reflection of a NIOSH/OSHA standards completion project. The recommendations contained in these sources, in general, need review by experts, because their basis is not always apparent.

The selection of history and physical examinations should be guided by basic precepts. The following precepts constitute a modification of principles originally suggested by Wilson and Junger (1968) for screening in the community. Examples are drawn primarily from the draft NASA medical surveillance data sheets for MOCA (4,4'-methylenebis(2-chloroaniline) and asbestos.

CHARACTERISTICS OF THE SCREENING TEST

1. There should be a suitable test system or examination and qualified personnel to interpret results. For example, chest x rays of asbestos-exposed workers should be read by B readers proficient in the diagnosis of occupational respiratory disease.

2. The tests need not be simple, as they must be for screening tests in the community. For example, assaying urine for MOCA or abnormal urinary cytology may yield appropriate early warnings of absorption or adverse effects and may be valuable as screening tests. However, neither is simple or inexpensive.

3. The screening test should be effective (with respect to sensitivity, specificity, and predictive value) for the population and the specific exposure. For example, a chest x ray of an asbestos-exposed worker is unlikely to detect abnormality in the first decade of exposure and hence is an insensitive early measure of hazard or effect.

4. Risks inherent in the screening test should be weighed against possible benefit. For example, the value of a chest x ray of an asbestos-exposed person in the first decade of exposure should be weighed against the adverse affect of the radiation.

5. The screening test should be targeted to the specific risks of the exposed population. For example, MOCA is not known to be a lung carcinogen, so sputum cytology analysis does not seem related to the effect of the exposure.

6. The screening test should be acceptable to the population. Some workers may see questions concerning family history of cancer or menstrual history as unnecessary invasions of privacy unless a clear relationship to MOCA-associated disease can be shown. The employee population should also be informed of the relationship between the hazard being screened for and the test.

CHARACTERISTICS OF THE DISEASE TO BE SCREENED FOR

7. The condition screened for should be important to the individual or the community. At the extremes, fatal diseases, such as lung cancer, are clearly important, whereas some manifestations of chronic trauma, such as writer's callus, are less important. Between these extremes, the importance of a disease either in the individual or in the community is a matter of judgment.

8. There should be an accepted treatment for patients with recognized cases of the disease screened for, or the screening data should be useful in improving prevention in other workers similarly exposed. In the community, lung cancer would not be sought through screening, because earlier diagnosis and therapy would be of little added value. However, a lung cancer in the workplace can indicate excessive exposure. Screening for nontreatable disease is appropriate in the workplace if the data generated will be taken as a reflection of the adequacy of protection of other workers who are similarly exposed.

9. The disease screened for should be detectable during a latent or asymptomatic stage. For example, through urinary cytology, it may be possible to detect a bladder cancer before symptoms appear. However, if a disease can be detected only at the time of usual clinical examination prompted by the onset of symptoms, there is no role for screening.

10. The natural history of the disease screened for, including development from latency to manifestations, should be adequately understood. For example, the frequency of chest x rays to detect asbestos-associated cancer should depend on the length of the presymptomatic stage of the disease. Without an understanding of the natural course of the disease, the timing of screening tests is guesswork.

11. There should be a policy on the abnormal test results that would prompt action. Many tests will have a continuum of results. Whether these tests are unusual (e.g., urinary MOCA) or more common (e.g., liver function), guidelines should be offered to the occupational physician on what action to take for specified degrees of abnormality.

CHARACTERISTICS OF THE WORKPLACE DISEASE-PREVENTION PROGRAM

12. Other methods for primary prevention of occupational disease should already be in use when a medical screening program is proposed. The prevention of occupational disease depends on a continuation of measures that include chemical selection, premarket testing, substitution, engineering controls, environmental monitoring, personal protective devices as masks and gloves, biologic monitoring for the absorption of a toxicant or its metabolite, medical screening, and clinical care. Medical screening is a secondary means of prevention, inasmuch as the disease process has already been initiated.

13. Facilities for diagnosis or treatment should be available, as well as counseling and other support services for cases of nontreatable disease. Screening programs generate information that is of importance to individual workers. Before screening is instituted, there should be plans for caring for workers with true or false-positive results, which are inevitable in a screening program.

14. The dual purposes of screening programs--individual diagnosis and worker-population assessment--should be recognized and specified for each program when it is undertaken. When the goal is assessment of the health status of the worker population, the screening data should be analyzed epidemiologically.

The substance of the history and physical examination is influenced by the nature of past, current, and potential exposures. The preplacement examination provides a baseline for evaluation of past exposures and evaluation of the suitability of a worker for exposures to be encountered in the new work situation. The periodic

examination helps in evaluating the effects of exposures in the immediately preceding work period and the long-term effects of earlier exposures. The frequency of evaluation of the effects of past exposure should be based on knowledge of the natural history of the disease processes. These followup examinations need not be done at every regularly scheduled periodic examination. In giving a history, the patient should be queried about illness that may have developed and resolved between periodic examinations. For example, the occupational physician looking for cancer of the skin may find none on examination, but may find that the patient has had a tumor diagnosed and excised by a personal physician in the interim between periodic examinations. Finally, the termination physical should include a comprehensive evaluation of all effects of past exposures since the last periodic examination.

LABORATORY TESTS

Wilson and Jungner (1968) developed a set of principles for screening for disease that apply to periodic health surveillance of apparently healthy people, but do not apply in every particular to medical screening in industry for workplace hazards, as pointed out by Halperin et al. (1982). In addition to detection of significant and treatable disease, screening for workplace hazards must detect hazards that may be prevented by minimizing further exposure of those tested and their co-workers. In population screening, simple inexpensive tests are desirable; but in screening for occupational hazard, the most effective test should be used.

In selecting laboratory tests for screening, important test characteristics should be taken into account (Galen and Gambino, 1975), such as diagnostic sensitivity, diagnostic specificity, and positive and negative predictive values. Diagnostic sensitivity is the ratio of true positives--the number of persons with the condition sought who yield a positive test result to the number of persons tested who have the condition sought. It answers the question: "What is the likelihood that a patient with a given condition will have a positive test result?" Diagnostic specificity is the ratio of true negatives--patients without the condition sought who yield a negative test result to the number of persons tested who are free of the condition sought. It answers the question: "What is the likelihood that a person without a given condition will yield a negative result?"

While considerations of diagnostic sensitivity and specificity are important for test selection, they are not the values that are helpful in analyzing a test result. In this process, one wishes to know the probability that a given positive test result indicates that disease and the probability that a given negative test result excludes disease. These probabilities are known as the predictive values of a positive and negative test result. The predictive value of a positive test is defined as the percentage of positive test results that are true positives when the test is applied to a population of subjects

which includes individuals with and without the disease being sought. The predictive value of a negative test is the percentage of negative tests that are true negatives under the same circumstances as described for positive tests. Both of these values depend not only on the diagnostic sensitivity and specificity of the test, but also heavily on the prevalence of the disease sought in the population tested.

If a test were perfect, it would be positive only in persons who have a disorder resulting from the hazardous agent under consideration and negative in all persons without any injury due to the hazardous agent. Few tests in reality give such a good result. In general, there is a considerable overlap of injured persons and those without any impairment due to the injurious agent. This overlap of those with and without injury presents a problem in screening. It is important to use judgment and care in picking a cutoff point between those judged normal and those judged abnormal. For example, if one is considering an agent potentially injurious to the liver, one might use serum gamma-glutamyltransferase (GGT) activity to monitor potential hepatotoxicity. An increase in GGT activity would be a sign of liver injury. In using the test, one might examine 25 normal people and 25 people with liver injury. A frequency distribution of results could than be plotted, and a biphasic curve noted (see Figure 1). A high cutoff point between normal and abnormal might be chosen if one wanted to diagnose the condition of "liver toxicity" with assurance (high diagnostic specificity). An appreciable number of cases of liver toxicity would be missed under these circumstances but scarcely any normal persons would be included in the abnormal group. If the cutoff point were so low as to rule out the presence of liver toxicity in the normal group, an appreciable number of normals (false-positives) would be included in the liver-toxicity group. Unless further tests were done to separate normals and abnormals further in the toxicity group, many normal persons might be excluded from the workplace without justification. It is usual in screening to attempt to "rule out" disease, so the cutoff point selected is usually low.

One of the better ways to choose a cutoff point is that proposed by McNeil et al. (1975), the so-called receiver-operator-characteristic (ROC) curve (see Figure 2). In this construction, the true-positive ratio is plotted against the false-positive ratio for the test. Cutoff points to meet the needs of a particular testing situation can be easily selected on the basis of such graphs.

Sunderman (1970) has pointed out that increasing the number of tests increases the number of abnormal results found in a normal, healthy person (see Figure 3). For this reason, it is important to target tests well, so as to avoid many false-positive results when the tests are used to detect health problems related to the workplace. The specific hazards should be known and the tests targeted to them and their toxic consequences.

Review of sample NASA medical surveillance data sheets suggests that test procedures recommended in them often lack desirable sensitivity and specificity and are not targeted to consider the toxicity of each agent. The Subcommittee has pointed out some desirable characteristics of screening tests and precepts that should guide their selection and implementation. It recommends that the laboratory tests identified in the NASA data sheets be thoroughly analyzed by persons fully conversant with the toxic properties of specific agents for consistency with the principles described above and with promulgated OSHA standards. Detailed comments on review mechanisms suggested by the Subcommittee are provided in Chapter 5.

WORKER EDUCATION

The goal of worker education is twofold: to enlist the cooperation of the worker in the proper handling of industrial hazards and, to alert the worker to the early signs and symptoms of exposure so that diseases can be detected as early as possible. Just as a prescribing physician will offer to a patient a fact sheet on how to take a medicine and on its adverse reactions or side effects, so should workers be informed on occupational hazards they encounter. Information on the interaction of personal habits (such as smoking and consumption of alcoholic beverages) with occupational hazards should be provided. Particular attention should be paid to the termination examination. Many occupational diseases have long latent periods, so an ordinary history and physical examination in no way ensure that disease will not occur after termination of employment.

Employees should be educated on the specific nature of occupational diseases so that, if one occurs, it can be appropriately diagnosed, treated, and reported.

Information from medical surveillance testing and environmental monitoring should also be provided to employees. The need to know the agents to which one is exposed is sometimes in conflict with corporate needs to protect trade secrets. When it is legally impossible to inform workers fully of their exposures, they should at least be fully informed of the potential adverse consequences of exposure.

The capacity of workers to understand and act on complex information should not be underestimated. They should know the nature of the hazards they encounter, should be advised on how to minimize injury and illness through such measures as containment and safe handling, and should be informed about possible adverse health effects. Once informed, the workers may well play a valuable role in disease prevention.

NASA HEALTH INFORMATION SYSTEM--ASSESSMENT OF CURRENT SYSTEM AND RECOMMENDATIONS FOR THE FUTURE

NASA is involved in the development and implementation of a broad health surveillance system and a uniform health information system that will be applicable to its administrative, scientific, and other employees at the various space centers. Of particular concern in this connection are employees who work in environments with known or potential exposures to hazardous chemical, physical, or biologic agents. Preplacement medical examinations, as well as periodic and episodic health surveillance procedures, are provided as stipulated by OSHA or as indicated in the opinion of the large staff of contract physicians, nurses, industrial hygienists, etc., concerned with occupational health and environmental protection at the space centers.

The Subcommittee's task was primarily to aid NASA in the development of medical surveillance data sheets on some 55 agents for which there is potential exposure in the workplace. Although the emphasis was on the design and adequacy of the medical history, physical examinations, laboratory tests, and toxicity information contained in the data sheets, the Subcommittee believed it was also necessary to evaluate health surveillance procedures in general and to provide guidance for the local centers and a central health information system.

Currently, NASA conducts preplacement and periodic examinations and monitors and records exposure levels for various agents. If action levels are reached, further medical information is obtained. As part of the examinations, certain items of medical history and laboratory tests are specified. Laboratory findings outside normal limits are recorded, as are clinical impressions and diagnoses. No private physicians's input on job-related or non-job-related events is required or collected. Retired personnel are not routinely followed, nor is information from death certificates and autopsy reports routinely collected.

Information is collected and filed in separate local NASA facilities and rarely serves as a basis for systematic review of possible toxic effects or preventive practices or even for reassurance as to the absence of toxic effects. On occasion, exposure levels and examination results have been compared, but only with considerable effort and time. Although various industries, elements of the Department of Defense, and perhaps individual NASA contractors are concerned with efforts to provide information on health and occupational exposures, there is little linkage or sharing of information among these entities.

When one considers the substantial cost of health maintenance and occupational-health surveillance, it is unfortunate that the relatively small additional amount necessary for data collection, storage, linkage, and analysis is not available. Such treatment of the data could benefit employees and further toxicologic and epidemiologic knowledge. What is needed is a standardized system for all NASA units, covering event coding structures; inclusion rules; occupational classification (with specifications of hazardous exposures); the linkage of results of preplacement and periodic examinations with exposure data, diagnoses made during emergency and ambulatory care, and summaries of inpatient care; and periodic followup, with death certification and, when available, autopsy diagnoses. Recent reviews on medical recordkeeping as a resource for clinical care and for epidemiologic investigations (Kurland and Molgaard, 1981) and on the state of the art of occupational-health information systems (Finucane and McDonagh, 1982) are available.

Bringing together the elements described above as a standardized health information system throughout NASA can contribute to the following:

- Improved health maintenance of NASA personnel.
- Improved personal health services of NASA personnel.
- Improved recognition of the short- and long-term effects of exposure to known and unsuspected physical and chemical agents.
- Improved health planning and improved use of medical and industrial-hygiene personnel and programs.
- Improved clinical and epidemiologic research as a result of the proposed record linkage.

The Subcommittee suggests that NASA develop a population-based health-information system, in a standardized format, that will provide a longitudinal health and safety record on NASA employees. This system would combine health information collected throughout and after NASA employment, as well as occupational and environmental monitoring during employment. The system should enroll personnel at the time of employment, include data from a baseline health asssessment and occupational history, include diagnostic and procedure information from ambulatory and inpatient services, and provide followup information, including time, place, and cause of death. This system should be standardized to provide information linkage between worksites and the locations at which medical care is received.

The following must be known if the goals referred to above are to be met:

- The demographic characteristics of the NASA population--age, sex, race, worksite, and tasks.
- Background exposure levels and episodic variations in exposure.
- Health-care results (clinical and laboratory findings), with emphasis on diagnosis as indexed in a system like the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM).

- Information on medical and surgical problems; time, place, and cause of death; and postmortem findings obtained from followup throughout employment and, where feasible, after employment from periodic mail inquiry.

The proposed unified health-information system should have the following features:

- The system should be population-based, with enrollment of eligible personnel at the time of employment (or, for current employees, at the time of activation of this program). This will make possible the comparison of various occupational and other groups with respect to health status. If epidemiologic studies are to be conducted, they must be based on valid denominator information.
- The system should record occupational status and specific exposures in a standardized manner.
- Event coding should be standardized for diagnoses and surgical procedures and should use such disease classifications as ICD-9-CM; pathology coding could also use ICD-9-CM, although SNOMED (Standard Nomenclature of Medicine) should be considered. Immunizations and prescribed drug coding with standardized pharmaceutical numbers would be desirable for recognition of short- and long- term adverse effects of drugs, as well as of the potential of some drugs to confound toxicologic studies.
- The system should be suitable for employees' personal health care, as well as job-related events. If it is feasible, information should be sought especially from long-term employees who leave for health reasons or retirement; however, complexities in the private health-care sector may act to limit such information as that on time and cause of death.
- The data entry and storage system should be computerized and should use a record format that can be partially self-administered, but that is user-friendly and well tested.
- The concept of basic and optional data sets should be built into the system to maximize utility and flexibility. The basic system should include standardized registration and enrollment information, standardized event coding, and a standardized set of items--e.g. occupational status, health problems or complaints, diagnoses, and treatments. Optional features might include information particularly relevant to a particular worksite, group of personnel, or study situation.
- Because information must be collected from various administrative units--including health, personnel, and work units--such units should be represented in discussions designed to plan the system.
- If the plan is to be adopted, feasibility studies directed at the attainment of the specified goals are recommended. Exchange of information with the private medical-care sector, including health-maintenance organization (HMO) facilities and the military services, is desirable.

CONCLUSIONS AND RECOMMENDATIONS

The Subcommittee believes that a program to develop a series of medical surveillance data sheets for use by NASA physicians should have two goals: to present concise summaries of current information on the toxicity and health hazards of chemical, physical, and biologic agents that are of relevance to NASA and to provide specific guidelines regarding medical surveillance of exposed workers. These data sheets should reflect the leading edge of knowledge and practice in occupational medicine, presenting authoritative and up-to-date treatment of each agent in a capsule format. In meeting these objectives, the data sheets should not supplant standard texts, such as those available on industrial toxicology and occupational medicine.

The two sets of NASA medical data sheets reviewed by the Subcommittee meet these objectives to a large extent. The Subcommittee found aspects of both sets of drafts useful, and with some modifications these will be of immense value to NASA's occupational physicians. The following recommendations are offered to improve the quality of the individual data sheets and the guidance to physicians. More general comments are also offered on NASA's overall occupational-medicine program.

BASIC PRINCIPLES

It is important to identify a set of basic principles that will guide NASA's occupational-medicine program and, more specifically, guide the program in developing medical surveillance data sheets. Chapter 2 discusses the most recent reviews on the concepts related to general preplacement and periodic medical examinations. Chapter 3 suggests a set of principles for medical history and physical examinations, worker education, and laboratory investigations targeted to potentially hazardous agents.

GENERAL MEDICAL EXAMINATIONS

The procedures used by NASA for general medical examinations--both preplacement screening and periodic health examinations--were selected in an effort to provide for both personal health maintenance and early detection of work-related abnormalities. This approach has merit, and its goals are commendable. However, the Subcommittee believes that it tends to obscure the primary mission of the occupational-health team--to focus on the health effects of workplace exposure to potentially hazardous agents. When the broader scope of personal health maintenance examination is offered, the principles and issues identified in Chapter 2 should be considered.

GUIDELINES FOR SPECIFIC EXPOSURES

On the basis of its review, the Subcommittee offers the following suggestions with regard to the basic components of medical surveillance data sheets.

BACKGROUND INFORMATION

Although physicians are likely to have knowledge of some workplace hazards, most physicians are not likely to be thoroughly familiar with all potential hazards in the NASA workplace environment. Therefore, background information--such as that on uses, physical and chemical properties, and exposure--needs to be sufficiently addressed. Chapter 3 suggests types of information that should be included in the medical data sheets.

TOXICITY INFORMATION

The Subcommittee believes that the toxicity information in the medical data sheets should be presented in outline form, rather than narrative form, and patterned after a medical case history. The information should be authoritative, but not exhaustive; the objective is not to replace standard texts in the field. The information should be referenced and reflect up-to-date knowledge. The Subcommittee suggests an outline of this section in Chapter 3.

EXPOSURE HISTORY

Exposure histories should be complete and provide enough information to guide the occupational physician in assessing possible health risks associated with particular job assignments, in conducting periodic physical examinations, and in dealing effectively with accidental overexposures (appropriate interventions should be planned). The assistance of representatives of other specialties--such as toxicology, industrial hygiene, and safety engineering--will be needed to assess adequately the implications of particular exposures.

MEDICAL HISTORY AND PHYSICAL EXAMINATION

The Subcommittee has identified in Chapter 3 basic precepts that should guide the taking of medical histories and the performance of physical examinations. In particular, the Subcommittee believes that certain characteristics of screening tests, diseases to be screened, and workplace disease prevention programs should be considered. Examples of these characteristics are provided in Chapter 3.

LABORATORY INVESTIGATIONS

The Subcommittee found that many of the laboratory tests recommended in the sample NASA medical surveillance data sheets are

not in accord with basic principles for laboratory screening for disease. For any test, sensitivity, specificity, and positive and negative predictive values should be clearly understood. Each test should be carefully examined for its predictive value before it is recommended. Increasing the number of tests performed increases the likelihood of finding abnormal results in a healthy person. It is important to target the tests to avoid false-positives. Laboratory tests targeted to a particular agent should be recommended only after careful consideration of the principles described in detail in Chapter 3 and only by individuals fully conversant with the properties of the agent.

PREPARATION AND REVIEW OF MEDICAL DATA SHEETS

Information is constantly being generated in the field of occupational medicine. It is imperative that NASA develop a schedule for update and revision of the data sheets. The subcommittee believes that ideally the data sheets would be updated every 2 or 3 years.

To be accepted by NASA's physicians, the information provided in the data sheets must be authoritative. Peer review of the data sheets before they are sent to physicians is essential. Ideally, to ensure quality, each data sheet would be prepared by toxicologists, physicians, and others who are thoroughly familiar with the literature on the agent in question.

Several government agencies and other organizations have instituted peer-review systems to assist in the preparation of technical documents; such a system should be instituted by NASA. The Subcommittee recognizes that establishment of a separate panel for each data sheet would likely be too cumbersome and difficult to do, both logistically and financially. It is recommended that panels instead be formed for classes of hazards. Each panel would consist of members of the scientific community selected for their competence in fields relevant to an assessment of the medical data sheets, such as toxicology, occupational medicine, clinical pathology, and clinical medicine.

Several possibilites are available with regard to the location of the review panels. NASA can establish its own expert panels, with appointment of members being made by the agency director or another appropriate person. Procedures should be established to ensure each panel's objectivity and currency in the field. Examples of other procedures for selection of members of expert panels include suggestions provided by the President of the National Academy of Sciences, directors of institutes of the National Institutes of Health and the National Science Foundation, and appropriate professional societies.

Expert review panels could also be established outside NASA. The Subcommittee suggests, as two possibilities for consideration, the National Academy of Sciences-National Research Council and the

National Institute for Occupational Safety and Health. Regardless of which peer review system is selected, the names of the authors and reviewers of a medical data sheet and the date of completion should be stated on the data sheet.

NASA OCCUPATIONAL-HEALTH INFORMATION SYSTEM

In addition to providing specific guidance on the development of medical surveillance data sheets, the Subcommittee examined the data sheets in the context of an overall occupational-health system. Chapter 4 identifies the objectives of such a system. Specific recommendations are provided there to develop a population-based health-information system that will provide, in a standardized format, longitudinal health and safety records on all NASA employees. The Subcommittee is aware that NASA has begun to explore the institution of such a system and encourages activity in this direction. In view of the substantial expenditure for health maintenance and occupational health surveillance, the Subcommittee believes that it would be well worth the relatively small additional cost to ensure medical data collection, storage, and linkage that would benefit both employer and employee and improve clinical, epidemiologic, and toxicologic evaluations.

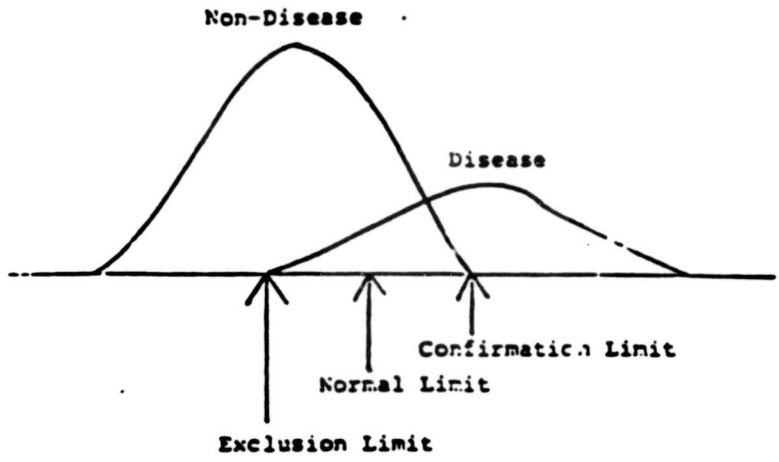

FIGURE 1. Frequency distributions of results of a given test in patients with and without a given disease. Note overlap between two distribution curves.

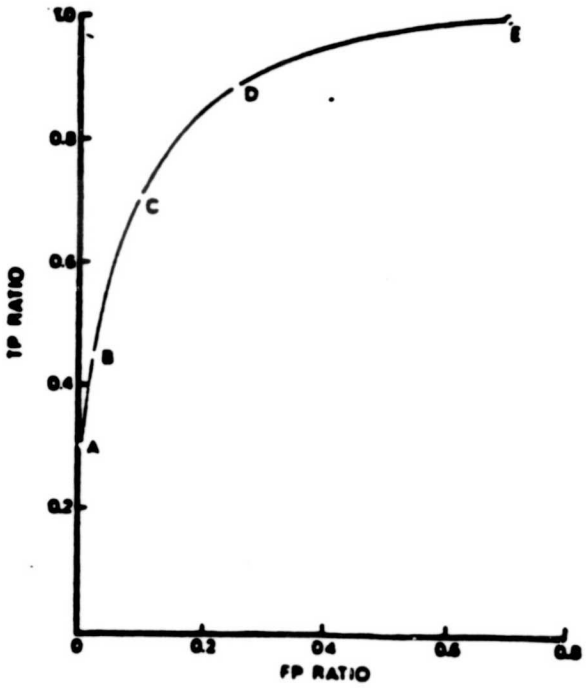

FIGURE 2. Receiver-operator-characteristic (ROC) curve. True-positive (TP) ratio is plotted against-false positive (FP) ratio. True-positive ratio = (number positive tests in patients with disease/number patients with disease tested). False positive ratio = (number positive tests in patients without disease/number patients without disease tested). If condition sought (for example, consequence of workplace hazard) is severe, cutoff will be selected near point E; if it is relatively trivial, cutoff will be selected closer to point A. ROC curves can also be used to compare tests for effectiveness in detecting a disease or exposure. The test that gives an ROC curve closest to the upper left-hand corner of the graph is the preferred one (it will have a better true-positive ratio for every false-positive ratio). Reprinted with permission from McNeil et al., 1975.

TABLE 1. EFFECT OF INCREASING NUMBER OF TESTS ON LIKELIHOOD OF OBTAINING ABNORMAL RESULTS IN NORMAL PERSON

Number of independent tests	Percentage of times an abnormal result is found
1	5
2	10
4	19
6	26
10	40
20	64
50	92
90	99

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